Environmental Toolbox

Technical Module

Water and Wastewater Management

Objectives

- Understand the importance of water and wastewater management
- Be familiar with common water and wastewater management procedures
- Assemble data to make informed choices concerning water reuse, recycling, and treatment
- Be familiar with alternatives that are appropriate for base camp conditions
- Be aware of future technologies

Definitions

- Potable water: water that is fit for human consumption
- Disinfected water: water that has been treated with chlorine to remove pathogens, but does not meet potable standards
- Untreated water: water from surface or aquifers that has not been treated
- Wastewater: water changed in its characteristics by domestic, commercial, agricultural or other use
  - Gray water: wastewater from laundry, showers, dining facilities, hand-washing devices, wash racks
  - Black water: water contaminated with animal or human fecal matter

Significance and Benefits

Good water and wastewater management can:

- Act as a force multiplier: when fewer soldiers are needed to resupply water, more soldiers are available for the mission
- Help meet mission requirements
- Prevent health problems
- Reduce water demand and wastewater generation, which decreases resupply risks and costs and increases security
- Demonstrate good stewardship of water resources
- Minimize legal liability
- Develop trust with the local community

Environmental Officer (EO) Responsibilities

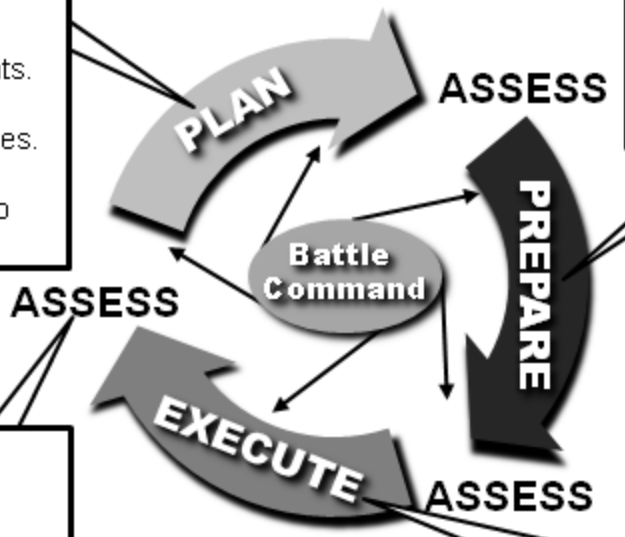
- Work with medical officer to evaluate water quality and potential use and reuse
- Make recommendations on
  - Suitable treatment technology
  - Potable water source
  - Water conservation practices
- Work with base engineer to integrate water considerations into base master plan
- Monitor wastewater to ensure it meets applicable effluent standards
- Maintain records of disposal locations
- Manage contracts as required

Integrated Water and Wastewater Management

- Water supply and wastewater treatment are inter-related and must be managed as a system
- Wastewater reuse and recycling reduces water requirements
- Once wastewater is treated, it can be reused for other purposes
  - The specific use depends on the level of treatment
  - The EO needs to coordinate with the commander and medical officer to determine the approved reuse

Water and Wastewater Management Process Overview

- Apply the 6-step process for developing a waste management plan:
  - Analyze the situation.
  - Develop preliminary waste requirements.
  - Categorize waste requirements.
  - Evaluate waste management capabilities.
  - Generate solutions.
  - Integrate waste management tasks into plans and orders.



- Facilitate subordinates' planning.
- Refine the waste management plan based on new information and changes in the situation.
- Monitor the progress of ongoing waste management tasks.

- Manage the execution of the waste management plan:
  - Construction management.
  - Contract compliance.
  - Quality assurance/quality control.
- Monitor the situation:
  - Changes in the duration of the mission.
  - Base camp establishment, realignment, and closure.

- Monitor the performance of waste management systems.
- Assess effectiveness and appropriateness.

Waste Management Plan

In a waste management plan, all waste management aspects must be dealt with. The waste management plan must comprise at least the following aspects:

a) A list and map depicting wastewater generation activities/locations, including relevant information (e.g., points of contact)
b) A list of the types of wastewater, including estimated quantities and disposal capacities
c) Necessary safety and health information applicable to specific wastewater generated
d) A list of local authorities, local laws and regulations and approved local contractors
e) Identification of wastewater by different categories
f) Procedural instructions for safe handling and disposal
g) Assignment of responsibilities within the military sector

Six-Step Development Process

- Initial considerations
- Six-step development process
  1. **Analyze the situation:** to include security level, location, duration, size, geology and economy
  2. **Develop preliminary waste stream estimates:** gray water and black water
  3. **Categorize waste requirements (time-scale):** appropriate methods are based on mission duration
  4. **Evaluate water and wastewater management capabilities:** HN and/or contractors' abilities, equipment options, etc.
  5. **Generate solutions suitable for the mission:** solutions must meet mission requirements
  6. **Integrate water and wastewater management tasks into plans and orders**
- Continue to monitor

Initial Considerations

- Start planning early
- Fulfill current requirements and anticipate future needs
- Site location
  - Maximize gravity flow for wastewater collection systems
  - Site wastewater collection, treatment and disposal downwind of inhabited areas
  - For surface discharge, locate downstream of your potable water intake
- Efficient water distribution systems
  - Loop systems versus branched networks to build in redundancy and minimize pumping requirements

Analyze the Situation

- Goal: understand how, where, and how much wastewater will be generated by the unit
- Considerations
  - Mission
  - Local threat conditions
  - Terrain and weather
  - Troops and support available
  - Time
  - Civil considerations
  - Available infrastructure
  - Others

Water Usage Planning Factors

Function	Water Usage Factor (liters/person/day)	
	Short-term	Long-term
Potable Water		
Drinking	15	15
Personal Hygiene	11	11
Shower	11	55
Food Preparation	15	20
Hospital	4	8
Heat Treatment	4	4
Nonpotable Water		
Laundry	19	53
Construction	8	8
Graves Registration	2	2
Vehicle Operations	2	7
Aircraft Operations	8	11
Firefighting	8	15
Subtotal	107	209
10% Loss Factor	11	21
Total	**118**	**230**

Develop Preliminary Wastewater Estimates

Source	Liters per person per day	
	Short-term	Long-term
Latrines	30	30
Showers	19	57
Food Preparation	15	19
Hospital	4	4
Laundry	8	53
Total	**76**	**163**

Consider Duration of Mission

- Short (sustain operations for a minimum of 60 days)
- Medium (Approximately 60-180 days)
- Long (more than 180 days)
- Closing

Evaluate Wastewater Management Capabilities

- Can your unit meet its water and wastewater requirements?
- Does your unit have adequate resources to include:
  - Manpower
  - Equipment
  - Materials
  - Funding
- Identify potential shortfalls
  - What are HN and/or contractor capabilities to address these shortfalls?

Generate Solutions

- Determine potential solutions that are:
  - Feasible
  - Suitable
  - Sustainable
- If contracting is required, ensure environmental considerations are included:
  - Performance work statement
  - Monitoring and evaluation plan
- Evaluate options and present at Environmental Management Board (EMB) for Commander's decision on the approved course of action (COA)

Integrate Water and Wastewater Management into Plans and Orders

- Finalize the water and wastewater management plan that supports the approved COA
- The plan should contain the who, what and when for each step in the process:
  - Demand/reduction
  - Recycling/Reuse
  - Conveyance
  - Treatment
  - Disposal

Examples of Demand Reduction Practices and Equipment

- Practices
  - Water recycling and reuse
  - Good maintenance of water lines and storage
  - Rainwater collection
  - Education and awareness
- Technologies
  - Low flow and timed shower heads
  - Tankless water heaters
  - Composting toilets (suitable for use in low demand areas)
  - Plumbing with built-in waste segregation
  - Waterless urinals
  - Water meters - if you know how much you are using, you tend to conserve more

Methods for Obtaining and Treating Water

Bulk Water Delivery

- Advantages
  - Less packaging
- Disadvantages
  - Expensive
  - Transportation cost/risk
- Limitations
  - May require additional treatment
  - Limited community supplies may restrict availability
  - Limited shelf life

Duration Suitability Index

Short	Medium	Long

Bulk Water Delivery

General Design Considerations	•Protected storage bags or tanks •Locate storage near points of use: showers, latrines, dining facilities, etc.
Limitations	•Limited shelf life
Recordkeeping, Reporting	•Water quality sampling records •If contractor provided, contract management required
Capital Costs	•Storage containers (bladders, tanks)
Operations and Maintenance (O&M) requirements	•Water quality sampling •Maintenance of storage •Freeze protection
Transfer/Closure Requirements	•Removal of storage containers •Terminate contract, if applicable

Bottled Water

- Advantages
  - No additional treatment
  - Convenient for users
  - Culturally acceptable
- Disadvantages
  - Expensive
  - Transportation cost/risk
  - Generates waste
- Limitations
  - Storage requirements
  - Limited shelf life

Duration Suitability Index

Short	Medium	Long

Bottled Water

General Design Considerations	•Protected storage space (from UV or freezing) •Disposal of plastic waste
Limitations	•Limited shelf life •Only a partial water demand solution (does not address showers, fire suppression, etc)
Recordkeeping, Reporting	•Tracking of shelf life
Capital Costs	None
O&M Requirements	•Materiel handling equipment •Controlled storage •Collection for recycling
Transfer/Closure Requirements	•Terminate contract

WATER TREATMENT
Reverse Osmosis (RO)

- Advantages
  - Effective with most sources
  - Removes all contaminants and pathogens
  - Short start up time
- Disadvantages
  - Energy inefficient
  - Requires specialized training
  - Noise
- Limitations
  - Requires up to 3 units of untreated water to create 1 unit of potable
  - Generates brine and wastewater streams
  - Chemical taste

Duration Suitability Index

Short	Medium	Long

Reverse Osmosis

General Design Considerations	•Space for treatment unit, waste brine pit, storage •Available power source •Locate near water source
Limitations	•Up to a 3:1 untreated to potable water •Higher power requirements than standard treatment •Generates large volumes of brine and wastewater •Only a partial water demand solution (cost prohibitive for fire suppression, vehicle washing, and other non-potable uses)
Recordkeeping, Reporting	•Water quality sampling records
Capital Costs	•RO unit •Storage tanks or bags •Generator if no central power generation
O&M Requirements	•Water quality sampling •RO unit maintenance •RO filter and membrane changes •Maintenance of storage •Waste brine disposal
Transfer/Closure Requirements	•Removal of tanks •Brine pit closure
References	•Air Force Handbook 10-222, Volume 9,1 April 2011 •Air Force Pamphlet 10-219, Volume 5, 30 March 2012

WATER TREATMENT
Filtration/Disinfection

- Advantages
  - Common technology, available worldwide
  - Removes most contaminants and pathogens
  - Lower energy and source requirements
- Disadvantages
  - Fixed facility, not portable
  - Contractor built/operated
- Limitations
  - Skilled operators required
  - Construction time

Duration Suitability Index

Short	Medium	Long

Filtration/Disinfection

General Design Considerations	•Space for treatment unit, storage •Available power source •Locate near water source •Available filtration media
Limitations	•May not be suitable for all water sources •Requires skilled designers and operators, may not be suitable for tactical uses
Recordkeeping, Reporting	•Water quality sampling records •Contract management
Capital Costs	•Treatment tanks, piping, filtration components •Storage tanks or bags •Generator, if no central power generation
O&M Requirements	•Requires skilled operators •Water quality sampling •Filter and membrane changes •Maintenance of storage tanks
Transfer/Closure Requirements	•Removal of tanks •Contract close out

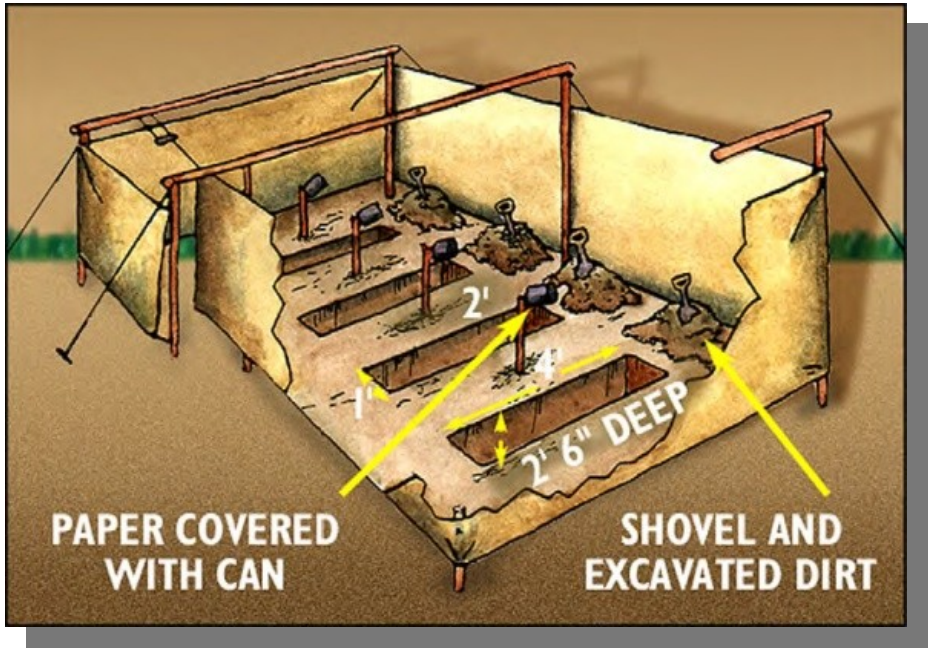
Wastewater Treatment and Disposal Methods

EXPEDIENT BLACK WATER TREATMENT: Latrines

- Advantages
  - Immediate implementation
  - Simple system
- Disadvantages
  - Only for short term use
  - Can attract vectors or pests
- Limitations
  - Requires periodic relocation

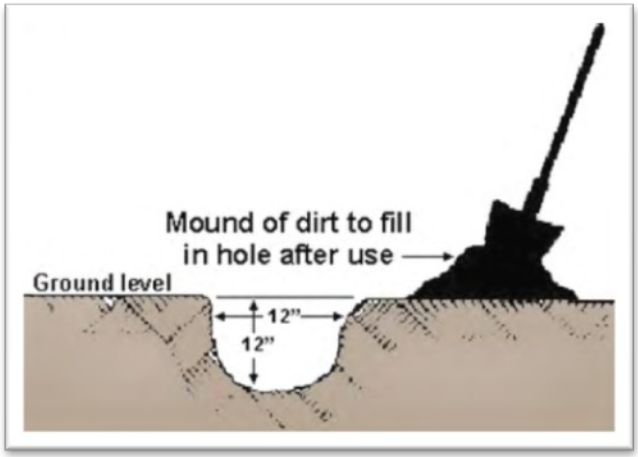
Duration Suitability Index

Short	Medium	Long

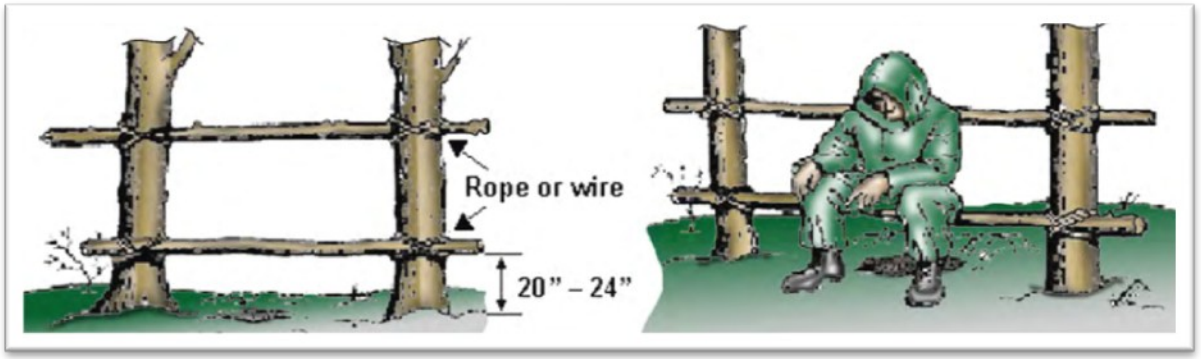


Expedient Latrines

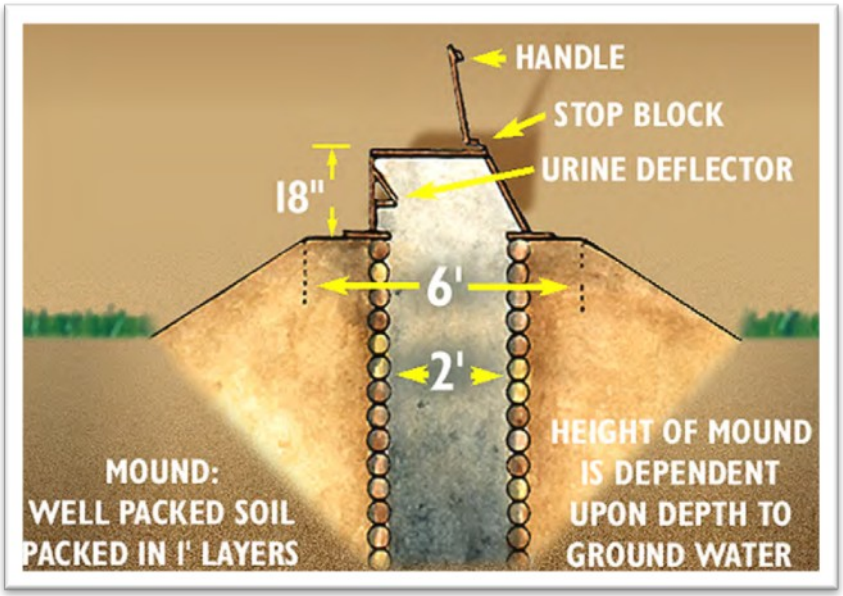
Cat Hole Latrine



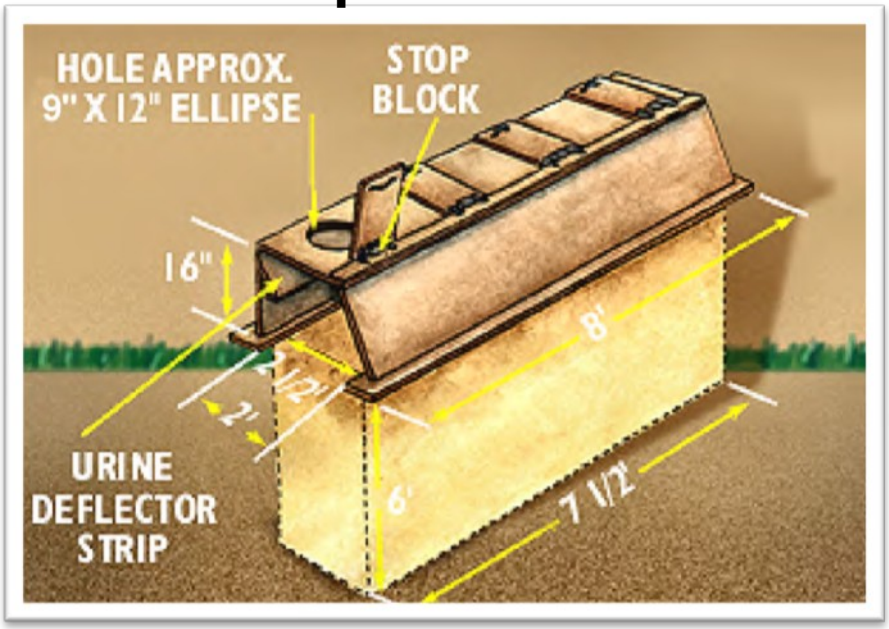
Cross Tree Latrine



Mound Latrine



Deep Pit Latrine



Expedient Latrines

Burn Out Latrine

Multiple-Station Burn Out Latrines

Typical Pail Latrines

Latrines

General Design Considerations	•Volume and area •Soil percolation rates •Downwind from living areas for odor and vector control
Limitations	•Only for short term use •Requires periodic relocation
Recordkeeping, Reporting	•Latrine location
Capital Costs	•Minimal
O&M Requirements	•Lime for daily covering of waste •Daily waste burning may be required
Transfer/Closure Requirements	•Burial •Location marking or reporting
References	•U.S. Army, Guidelines for Field Waste Management, Technical Bulletin Medical (TB MED) 593, September 2006 •Air Force Pamphlet 10-219, Volume 7, 9 June 2008

EXPEDIENT BLACK WATER TREATMENT: Chemical Toilet

- Advantages
  - Most hygienic expeditionary field method
  - Can be relocated
- Disadvantages
  - Must be emptied frequently
  - More expensive than other expeditionary methods
- Limitations
  - Contract support required
  - Procurement timeline may not meet expeditionary timeline

Duration Suitability Index

Short	Medium	Long

Chemical Toilet

General Design Considerations	• Number of toilets needed • Locations to properly place toilets balancing personnel convenience and aesthetic requirements (downwind, far from inhabited areas, etc.)
Limitations	• Contractor availability and capability
Recordkeeping, Reporting	• Contract management
Capital Costs	• May have to purchase toilets
O&M Requirements	• Must be frequently emptied and serviced (by contractor)
Transfer/Closure Requirements	• Remove toilets from site • Terminate contract

WASTEWATER TREATMENT: Host Nation (HN) Treatment

- Advantages
  - Low capital costs, only storage tanks
  - Low maintenance
  - Could use either HN collection or connection to local sewer
- Disadvantages
  - Potential high contract costs
- Limitations
  - HN must have capability and capacity
  - Lack of control over disposal
  - Contract management requirements
  - Quality assurance for compliance

Duration Suitability Index

Short	Medium	Long

HN Treatment

General Design Considerations	•Daily wastewater volume •May require waste transfer point •Consider pumping to trucks outside fence line •Temporary storage with pit, tanks or bags
Limitations	•May not be suitable in hostile areas •High contract costs and oversight requirements
Recordkeeping, Reporting	•Daily effluent •Contract management
Capital Costs	•Construction of storage and transfer point •Pumps
O&M Requirements	•Transfer point maintenance •Storage point maintenance
Transfer/Closure Requirements	•Contract payment and close out

WASTEWATER TREATMENT: Facultative Lagoon

- Advantages
  - Effective
  - Low maintenance
  - Least expensive for large volumes
- Disadvantages
  - Large space requirement
  - Can attract vectors or pests
- Limitations
  - Aircraft bird strike hazard (site away from airfields)
  - Temperature-dependent
  - Requires engineered design

Duration Suitability Index

Short	Medium	Long

Facultative Lagoon

General Design Considerations	•Lagoon volume and area •Consider making large enough for population expansion •Retention time for wastewater •Soil percolation rates •Downwind from living areas for odor and vector control •Effluent impact on base populace and surrounding communities
Limitations	•Base footprint may limit lagoon size •Effluent outflow may be limited
Recordkeeping, Reporting	•Daily inflow •Effluent sampling
Capital Costs	•Earthmoving equipment for excavation •Aeration pumps may be required
O&M Requirements	•Effluent sampling •Power for aeration (if necessary)
Transfer/Closure Requirements	•Drain effluent, remove liner (if applicable), remove and treat solids, spray with insecticide, backfill to allow drainage from site, install vegetative cover to prevent erosion •Location marking or reporting
References	Wastewater Technology Fact Sheet, Facultative Lagoons, http://water.epa.gov/scitech/wastetech/upload/2002_10_15_mtb_faclagon.pdf

WASTEWATER TREATMENT
Aerobic Lagoon

- Advantages
  - Effective
  - Low maintenance
  - Inexpensive for large volumes
  - Less odor than other lagoons
- Disadvantages
  - Large space requirement
  - Can attract vectors or birds
  - Needs impermeable liner or compaction
- Limitations
  - Aerator requires power
  - Aircraft bird strike hazard (site away from airfields)
  - Temperature-dependent
  - Requires engineered design

Duration Suitability Index

Short	Medium	Long

Aerobic Lagoon

General Design Considerations	•Pond volume and area •Climatic data to calculate evaporation •Consider making large enough for population expansion •Residence time for wastewater •Soil percolation rates •Downwind from living areas for odor and vector control •Effluent impact on base populace and surrounding communities
Limitations	•Base footprint may limit pond size •Effluent outflow may be limited
Recordkeeping, Reporting	•Daily inflow •Effluent sampling
Capital Costs	•Earthmoving equipment for excavation •Impermeable liner •Aeration pumps and generators
O&M Requirements	•Effluent sampling •Power for aeration
Transfer/Closure Requirements	•Drain effluent, remove liner, remove and treat solids, spray with insecticide, backfill to allow drainage from site, install vegetative cover to prevent erosion •Location marking or reporting
References	Wastewater Technology Fact Sheet, Aerated, Partial Mix Lagoons http://water.epa.gov/scitech/wastetech/upload/2002_10_15_mtb_apartlag.pdf

WASTEWATER TREATMENT
Anaerobic Lagoon

- Advantages
  - Effective
  - Low maintenance
  - Inexpensive for large volumes
  - Less capital cost than aerobic
  - Smaller space requirement
- Disadvantages
  - More odor than other lagoons
  - Longer retention time
  - Can attract vectors or birds
- Limitations
  - Aircraft bird strike hazard (site away from airfields)
  - Temperature-dependent
  - Requires engineered design

Duration Suitability Index

Short	Medium	Long

Anaerobic Lagoon

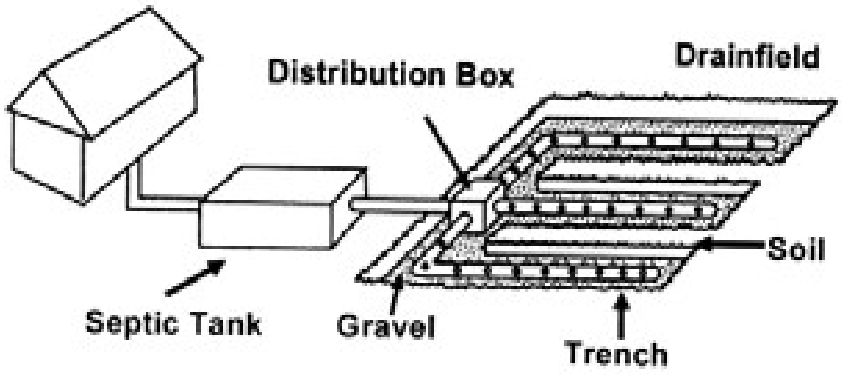
General Design Considerations	•Pond volume and area •Climatic data to calculate evaporation •Consider making large enough for population expansion •Residence time for wastewater •Soil percolation rates •Downwind from living areas for odor and vector control •Effluent impact on base populace and surrounding communities
Limitations	•Base footprint may limit pond size •Effluent outflow may be limited •Site much further from inhabited areas due to offensive odors
Recordkeeping, Reporting	•Daily inflow •Effluent sampling
Capital Costs	•Earthmoving equipment for excavation •Liner (if applicable)
O&M Requirements	•Effluent sampling
Transfer/Closure Requirements	•Drain effluent, remove liner (if applicable), remove and treat solids, spray with insecticide, backfill to allow drainage from site, install vegetative cover to prevent erosion •Location marking or reporting
References	US Air Force Pamphlet 10-219, Volume 5, Bare Base Conceptual Planning

BLACK WATER TREATMENT: Septic System

- Advantages
  - Effective
  - Low maintenance
- Disadvantages
  - Large space requirement
- Limitations
  - Lower soil percolation requires more land area
  - Dependent on water table height
  - Land cannot be used for other purposes

Duration Suitability Index

Short	Medium	Long



Septic System

General Design Considerations	•Daily wastewater volume •Soil percolation rates •Available area for septic field •Consider making large enough for population expansion
Limitations	•Base footprint may limit septic field size •Low permeable soils may make impractical •Not suitable for high groundwater table areas
Recordkeeping, Reporting	•Daily inflow
Capital Costs	•Earthmoving equipment for excavation •Septic tanks and perforated drain piping •Flow measuring device
O&M Requirements	•Septic tank cleaning and servicing
Transfer/Closure Requirements	•Septic field closure •Tank removal •Location marking or reporting
References	Septic Drain Field Design and Maintenance http://www.sera17.ext.vt.edu/Documents/BMP_septic_drain_field.pdf

WASTEWATER TREATMENT
Mobile Treatment Package Plant

- Advantages
  - Meets discharge standards
  - Smaller footprint than lagoon
- Disadvantages
  - High capital costs
  - Long procurement time
- Limitations
  - Must plan in advance if using for initial entry
  - Contract oversight

Duration Suitability Index

Short	Medium	Long

Mobile Treatment Package Plant

General Design Considerations	•Daily wastewater volume •Area for treatment unit and vehicle traffic •May require area for sludge disposal •Conveyance by pipes or vehicles •Can add new units to accommodate population growth •Downwind from living areas for odor and vector control •Effluent location and impact on base populace and surrounding communities •Requires dedicated power
Limitations	•Effluent outflow may be limited •Requires skilled operators
Recordkeeping, Reporting	•Daily inflow •Influent and effluent sampling •Contract management
Capital Costs	•High capital costs for plant •Construction of treatment area •Pumps •Flow equalization basin with large object removal (bar rack or grit screen)
O&M Requirements	•Influent and effluent flow volume and sampling •Mechanical maintenance •Sludge disposal
Transfer/Closure Requirements	•Unit removal •Location reporting

WASTEWATER TREATMENT
Fixed Treatment Package Plant

- Advantages
  - Meets discharge standards
  - Smaller footprint than lagoon
- Disadvantages
  - High capital costs
  - Long procurement time
- Limitations
  - Long-term bases only
  - Contract oversight

Duration Suitability Index

Short	Medium	Long

Fixed Treatment Package Plant

General Design Considerations	•Daily wastewater volume •Area for treatment unit and vehicle traffic •May require area for sludge disposal •Conveyance by pipes or vehicles •Consider making large enough for population expansion •Downwind from living areas for odor and vector control •Effluent location and impact on base populace and surrounding communities •Requires dedicated power
Limitations	•Effluent outflow may be limited •Requires skilled operators
Recordkeeping, Reporting	•Daily inflow •Influent and effluent sampling •Contract management
Capital Costs	•High capital costs for plant •Construction of treatment area
O&M Requirements	•Influent and effluent flow volume and sampling •Mechanical maintenance •Sludge disposal
Transfer/Closure Requirements	•Transfer to Host Nation

Gray Water Recycling and Reuse Methods

GRAY WATER REUSE
Shower Water Reuse System

- Advantages
  - Reuses 75-80% of gray water
  - 7-day unattended operation capability
- Disadvantages
  - Higher capital costs
  - More maintenance than regular showers
  - More power needed to operate RO unit
- Limitations
  - May not be widely available

Duration Suitability Index

Short	Medium	Long

Shower Water Reuse System

General Design Considerations	•Capacity to service number of personnel •On site water supply and storage •Dedicated power
Limitations	•Higher level use requires increased treatment, equipment, and trained, skilled personnel •Units are not yet widely available
Recordkeeping, Reporting	•Influent and effluent sampling
Capital Costs	•Water storage tanks or bags •Pumps, lines, treatment system
O&M Requirements	•Mechanical maintenance
Transfer/Closure Requirements	•Draining and repacking system

GRAY WATER REUSE
Vehicle Wash Rack

- Advantages
  - Reuses up to 50% of gray water
  - Integrated units commercially available
  - Can be constructed with ad-hoc equipment
- Disadvantages
  - Higher capital costs
  - More maintenance
- Limitations
  - Commercial units require contractor operation

Duration Suitability Index

Short	Medium	Long

Vehicle Wash Rack

General Design Considerations	•Vehicle types and numbers •Wash requirements – muddy locales require increased washing frequency and generate greater silt volume •Area for wash rack and settling ponds •On site water storage •Dedicated power
Limitations	•Must have appropriate level of use for recycled water •Higher level use requires increased treatment, equipment, and trained, skilled personnel
Recordkeeping, Reporting	•Influent and effluent sampling
Capital Costs	•Water storage tanks or bags •Pumps, lines, treatment system
O&M Requirements	•Mechanical maintenance
Transfer/Closure Requirements	•Wash rack removal •Location reporting

Conclusions

Good water and wastewater management can:

- Act as a force multiplier: when fewer soldiers are needed to resupply water, more soldiers are available for the mission
- Help meet mission requirements
- Prevent health problems
- Reduce water demand and wastewater generation, which decreases resupply risks and costs and increases security
- Demonstrate good stewardship of water resources
- Minimize legal liability
- Develop trust with the local community